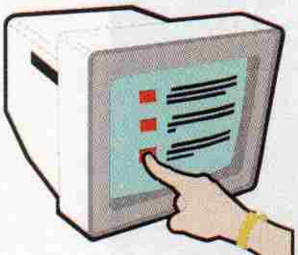
Using Technology to Enhance Cues for Children With Low Vision



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Most people with visual impairments have some functional vision that they can use to facilitate their mobility and independent functioning. The term "low vision" (see box "What is Low Vision") was introduced after World War II, when a distinction from totally blind was necessary to tailor specific rehabilitation services for veterans returning to the work force (Goodrich & Bailey, 2000). In 1964, Barraga extended these distinctions to children when she investigated the learning characteristics of Children with visual impairments who had some functional vision. She showed that children with low vision could increase the efficiency with which they used their vision for visual discrimination (Barraga, 1964).

Since the 1960s, we have witnessed a tremendous growth in technology that can support and enhance low vision. In this article, we review some of the existing technology that assists children with low vision in their ability to use environmental cues.

Framework for Services

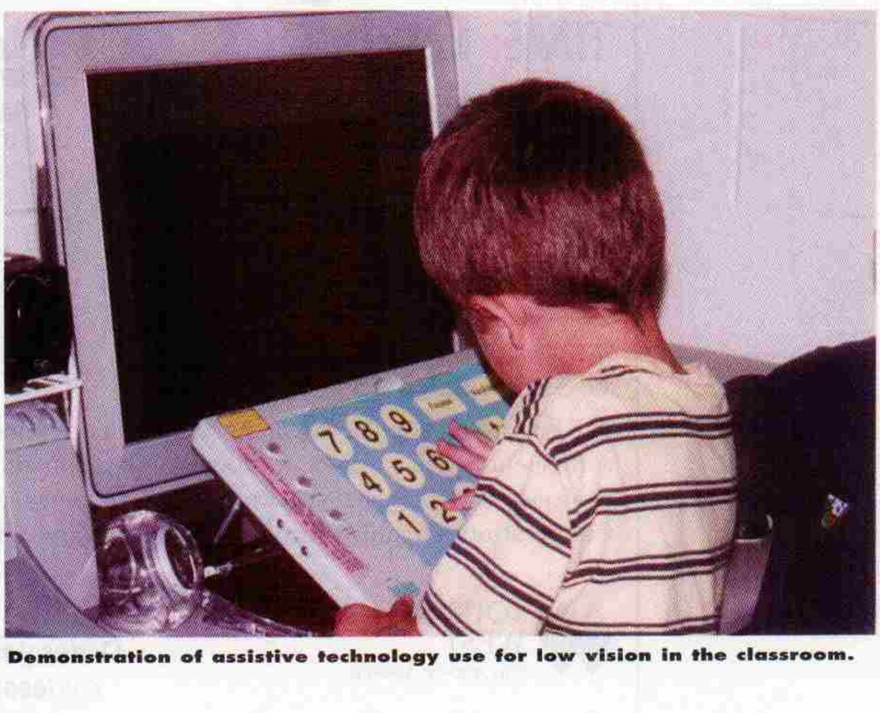
Recent research has emphasized that the education of children with low vision requires a transdisciplinary team effort (Wilkinson, Stewart, & Trantham, 2000). Such a team often includes the student, parents, technology consultant, orientation and mobility specialist, teacher of children with visual impairments, general education classroom teacher, and eye care professional. The team works together to provide services that will enhance the ability of children with low vision to utilize their residual vision.

Educators and researchers have proposed many models to guide decisions about service delivery and intervention plans. Colenbrander, Leigner, and Fletcher (1999) suggested that an effective model should consider lighting and contrast enhancement, as well as low-vision aids for near and distance magnification. Corn (1983) originally proposed, and later revised (Corn 1989), a model that focuses on visual abilities, individuality, and environmental cues (see Figure 1). We use this model as a framework for discussing technology applications that enhance the use of residual vision and independence for students with low vision.

Corn's Model

Corn's (1989) theoretical model for people with low vision consists of three interrelated components (see Figure 1), as follows:

- *Visual Abilities* consist of near-distance acuity, central and peripheral visual fields, and the mobility of the visual system. This component also addresses the functions of the brain that contribute to fixation, fusion,



Demonstration of assistive technology use for low vision in the classroom.

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What Is Low Vision?

Visual acuity is often categorized into three levels of functioning normal vision; low vision (moderate, severe, and profound); and blind.(near blindness and total blindness; Fletcher & Colenbrander, 1999). Only about 10% of people who are visually impaired are totally blind (Hollins, 1989). The remainder of this population has some vision. The term "low vision" is not defined easily. Low vision is used to describe people who are neither totally blind nor fully sighted. Low vision can be any condition in which a person's vision is not adequately meeting his or her needs (Kern & Miller, 1997). The Lighthouse for the Blind defined low vision or partially sighted as:

> A significant reduction of visual function that cannot be corrected to the normal range by ordinary glasses, contact lenses, medical treatment and/or surgery. The term "low vision" also is used to describe the service or intervention provided for those with partial sight. (Silverstone, Lang, Rosenthal, & Faye, 2000, p. 17)

In addition, Corn (1989) proposed a definition of low vision that focused on the potential functionality of vision:

> A level of vision which, with standard correction, hinders an individual in the planning and/or execution of a task, but which permits enhancement of the functional vision through the use of optical or non-optical devices, environmental modifications, and/or techniques. (p. 28)

Because of its direct applicability to the educational setting, we use Corn's definition as our basis of exploring technology that can enhance students' independent functioning.

awareness of motion, changes in the lens, and light and color reception.

- *Stored and Available Individuality* includes cognition, sensory development and integration, perceptual abilities, psychological organization, and physical characteristics of the individual.
- *Environmental Cues* include color, contrast, and time elements involved in the presentation of materials; spatial relationships; and illumination.

Corn (1989) contended that the ability to use low vision is related to all factors in the model and that the interaction of these factors leads to greater visual efficiency in students with low vision.

Using Environmental Cues

We feel that the use of assistive technology is most applicable to the "environmental cues" component of Corn's model. The number and array of possible applications of assistive technology are too numerous for the scope of this article. Therefore, we discuss only a sample of representative applications. Table 1 provides additional examples and vendor contact information. As is illustrated in Figure 1, Corn's model of environmental cues stresses the elements of color, contrast, time, space, and illumination.

Color and Contrast

Corn's first environmental cue includes several aspects of *color* (Lang, 1993). These aspects are hue, lightness, and saturation.

- *Hue* is the attribute of color names (red, blue, yellow) and is ordered as they are produced in the light spectrum.
- *Lightness* is the perceived intensity of a surface compared to nearby surfaces.
- *Saturation* is the perceived differences of the intensity of a color.

Knowlton and Woo (1989) cautioned that color deficits may not be fully detected in children with low vision. With better detection of these deficits, the environment can be arranged for successful completion of academic tasks. Teachers can enhance the use of color when working with students with low vision. Lang (1993) provided the following guidelines for effectively using color in materials:

Only about 10% of people who are visually impaired are totally blind.

- Use colors that differ as much as possible in lightness.
- Choose colors that reflect little light to use with colors from the middle of the light spectrum (light yellow with dark blue).
- Avoid colors from the ends of the spectrum with dark colors from the middle of the light spectrum (dark green with light red).
- Avoid white or gray with any color the same lightness (white and bright yellow).
- Avoid colors from adjacent spectrum areas (blue used with green).
- Avoid the use of pastel colors with each other (pale blue with pale pink).

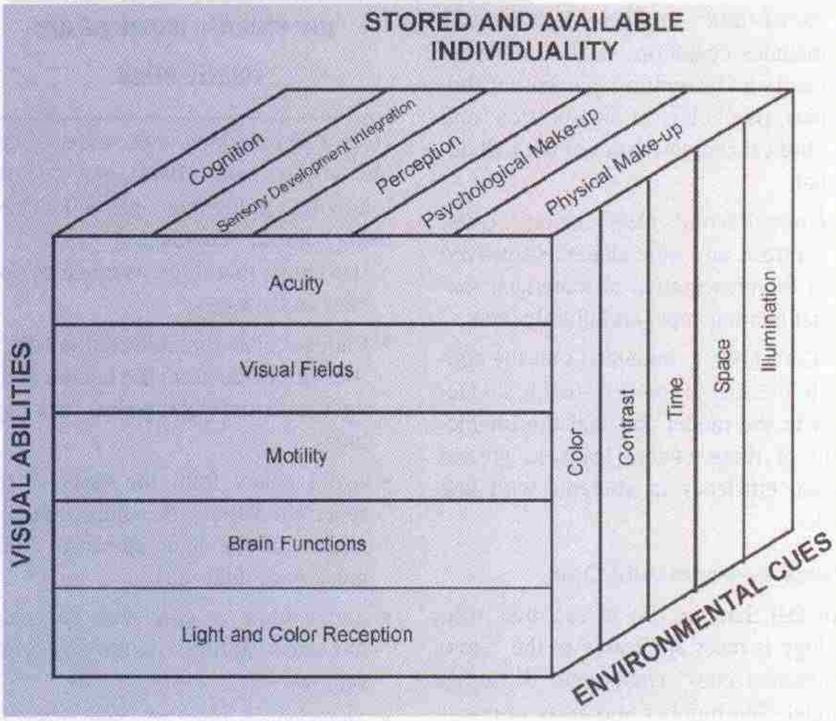
These suggestions also have implications for assistive technology choices. Write Outloud and Intellikeys are programs used by children, including those with visual impairments. These programs also address the color and contrast needs of students.

Designers of Web sites can emphasize color discrimination by keeping in mind these guidelines and the needs of people with low vision. In addition, color discrimination considerations can be combined with magnification.

The Reader Color XL (see Table 1) offers closed circuit television on a color screen and can provide magnification of 40 times that provided by hand-held devices. Barraga and Erin (2001), however, highlighted five concerns that educators should consider before buying a closed-circuit television: image, reliability, cost, versatility, and portability.

The education of children with low vision requires a transdisciplinary team effort.

Figure 1. Model of Visual Functioning



Lighting should always be a primary consideration in working with children with low vision.

Previously, closed-circuit television devices have not been portable, but Charters and Arai (1999) describe a new closed-circuit television (CCTV) that has been developed. This new CCTV is light and small, which makes it portable. It uses a display mounted on the user's head and a charge-couple device camera, both of which are very light (3 ounces and 7 ounces, respectively). Two disadvantages are (a) that users must move their heads in a straightforward position to avoid image fluctuations associated with high magnifications, and (b) the cost of the device (Charters & Arai). A variation of the CCTV is the Genie Pro CCTV (see Table 1), which can be used to enlarge images from a computer or videotape.

Illumination

Another environmental cue, *illumination*, includes the aspects of intensity, reflectance, distance of light sources, and the place of the light source in the light spectrum. Morgan et al. (1989) indicated that children with low vision vary in their need for illumination. Medlow (1993) further asserted that lighting should always be a primary consideration in working with children with low vision and often is used in conjunction with optical devices, color contrasts, and tactual cues.

Environmental cues stress the elements of color, contrast, time, space, and illumination.

Bright light may be a discomfort to children with some conditions (e.g., photophobia, a condition of extreme sensitivity to light). Brown (1997) suggested that the use of 60-watt bulbs in lights is ideal for contrast. Lower-watt bulbs do not provide enough light, whereas higher-power light bulbs can cause glare. Although this is a suggested level, the intensity of lighting needed depends on the child's eye condition, the use of the lighting, and the distance the source of light is from objects.

Educators also need to consider the amount of reflectance of light or glare from an object. Glare, both reflected and scattered, is light that has no visual function. Reflected glare is often generated by the glossy surfaces of cabinets, paper, or desktops. Scattered glare occurs as a result of light bouncing off of particles in the air (Medlow, 1993). Generally, toys and other objects that have a lot of glare should be avoided when working with this population of children. Changing the polarity of the color or print in closed-circuit television helps to reduce glare, and children who are bothered by scattered glare can wear caps, hats, visors, absorptive shields, and polarizing lenses.

Children with low vision should not directly face the light source because of a tendency to lose sight of people and objects in direct light (Morgan et al., 1989). Fletcher (1999) suggests that lighting is best when directed onto an object from behind children when glasses are used. When low-vision aids are used, lighting from beside children seems to be better in avoiding reflections of the surface being magnified. Additionally, Rosenthal and Williams (2000) suggest that lighting be adjustable so it can be moved to the side of the eye with the greatest amount of usable vision. Adjustable lighting, such as a table lamp, allows light to be under the control of the child. It can be moved closer and in line with information being viewed (Medlow, 1993). An assistive technology application for adjustable lighting is the use of illuminated magnifiers that allow a light source to be brought closer to print in combination with magnification.

Space

The *space* component of environmental cues in Corn's model (1989) includes size, patterns, outlines, and clarity. The interplay among these spatial elements makes a separate examination of each item difficult; thus, we will focus on the use of size to enhance patterns and outlines to provide clarity for the viewer.

Optical accommodations and devices can assist people in viewing the information in their environment. Optical aids, which can range from simple to complex, enlarge the spread of an image on the retina so the brain can more eas-

Table 1. Technological Assists for Environmental Cues

Environmental Cues	Technology Applications	Vendor/ Author Contact
Colors and Contrasts	Web site design	http://www.cast.org/udl
	Reader Color XL	Beyond Sight 5650 South Windermere Street Littleton, CO 80120 (303) 795-6455 http;//www.beyondsight.com
	Hand-held Closed Circuit Television (CCTV)	Texas School for the Blind & Visually Impaired 110 West 45th Street Austin, TX 78756 (800) 872-5273 http://www.tsbvi.edu
	Genie Pro CCTV	IANSYST Ltd. Fen House, Fen Road Cambridge CB4, 1UN, UK (800) 018-0045 http://www.iansyst.co.uk
Color	Learning Keys and Talking Typer for Windows	American Printing House for the Blind P.O. Box 6085 Louisville, KY 40206-0085 (800) 223-1839 http://www.aph.org
	Braille'n Speak	Freedom Scientific Blind/Low Vision Group 11800 31st Court North St. Petersburg, FL 33716-1805 (800) 444-4443 http://www.freedomscientific.com
	Open Book	Freedom Scientific Blind/Low Vision Group 11800 31st Court North St. Petersburg, FL 33716-1805 (800) 444-4443 http://www.freedomscientific.com
	Nomad	American Printing House for the Blind P.O. Box 6085 Louisville, KY 40206-0085 (800) 223-1839 http://www.aph.org
	Kurzweil	Kurzweil Educational Systems Group Lernout & Hauspie Speech Products U.S.A., Inc. 52 Third Ave. Burlington, MA 01803 (800) 894-5374 ext. 5037 http://www.kurzweiledu.com
	Outspoken (Mac); IBM Screen Reader (IBM)	ALVA Access Group, Inc. 436 14th Street, Suite 700 Oakland, CA 94612 (888) 318-2582 http://www.aagi.com

Table 1. Technological Assists for Environmental Cues *(continued)*

Environmental Cues	Technology Applications	Vendor/ Author Contact
Space	Versatile Image Processor	Jbliss Imaging System 100 West El Camino Real, Suite 68 Mountain View, CA 94040 (888) 452-5477 http://www.jbliss.com
	Large Print Display Processor	Telesensory, Corporation 520 Alamanor Ave. Sunnyville, CA 94085 (408) 616-8700 http://www.telesensory.com/
	JAWS (Job Access with Speech)	Freedom Scientific Blind/Low Vision Group 11800 31st Court North St. Petersburg, FL 33716-1805 (800) 444-4443 http://www.freedomscientific.com
	Xerox Products	http://www.xerox.com/
Illumination	Ocutech VESAF-Autofocus Telescope	Ontario Rehabilitation Technology Consortium Bloorview MacMillan Centre 350 Rumsey Road Toronto, Ontario M4G1R8 (416) 425-6220 http://www.oise.utoronto.ca/ortc/
	Jordy	Enhance Vision Systems 17911 Sampson lane Hunington Beach, CA 92647 (800) 440-9476 http://www.enhancedvision.com
	Magnicam	Innoventions, Inc. 5921 South Middlefield Road Suite 102 Littleton, CO 80123 http://www.magnicam.com
	Visual Scan	Hallogram Publishing 14221 E. 4th Ave., Suite 220 Aurora, CO 880011 (303) 340-3404 http://www.hallogram.com/
	Zoomtext Xtra	Ai Squared P.O. Box 669 Manchester Center, VT 05255 (802) 362-3612 http://www.aisquared.com/
	inLarge	ALVA Access Group, Inc. 436 14th Street, Suite 700 Oakland, CA 94612 (888) 318-2582 http://www.aagi.com
	Visolette	Eye Associates of Cayce/West Columbia, S.C. 600 Knox Abott Drive Cayce, S.C. 29033
	Lighting Aids	Optelec, Inc. http://optelec.com
	Illuminated Magnifiers	Dazor Manufacturing Corporation 4483 Duncan Avenue St. Louis, MO 63110 (800) 345-9103

ily identify and interpret objects. The size of an image can be enlarged without specialized equipment or hurting children's eyes by simply having the student hold materials closer. The style and spacing of letters can enhance the clarity of printed materials. For example, bold letters, which are spaced close together, are more difficult to read than smaller letters placed farther apart (Barraga & Erin, 2001).

Although simple optical aids may be as common as a magnifying glass or a Visolette, a low vision magnification aid (see Table 1), more sophisticated aids are increasingly available. Personal reading devices, such as Visual Scan and telescopes (Colenbrander et al., 1999; Moore, 2001) enlarge regular print such as that found in magazines, newspapers, forms, and worksheets. Other personal reading devices are manufactured by a variety of companies, including Xerox, Telesensory, Inc., Innoventions, Inc., and Ai Square ("Living with low vision," 1999; Moore). The use of optical aids with regular-size print makes more material available to people with low vision, and they are easier to carry and store than bulky, large-print books (Barraga & Erin, 2001).

People with low vision can use telescopes to see at varying distances. Some of these telescopes are designed to be head mounted, such as the Jordy by Enhanced Vision Systems, and the Ocutech VESAF Autofocus Telescope (see Table 1). Geruschat, Deremeik, and Whited (1999) found that head mounted displays provided variable magnification and allowed the user to adjust from one distance to another without manually adjusting the aid. Head-mounted displays also provide enhanced contrast sensitivity, prevent glare, and help people with low vision interpret near, intermediate, and distant items.

Optical aids, which can range from simple to complex, enlarge the spread of an image on the retina so the brain can more easily identify and interpret objects.

Magnifications can often be altered for individual needs through the use of computers. Users can modify screen and print-size magnification by using display options. Lewis (1993) reports that the Large Print Display Processor by Telesensory (see Table 1) allows on-screen text to be enlarged up to 16 times. Other technology that can be used with computers includes Zoomtext Extra, Inlarge, and JAWS (Lisciecki, 1999).

- *Zoomtext Extra* (combination of Level 1 and Level 2) has the capability to enlarge up to sixteen times the normal screen size as well as incorporate screen reading and enlarging.
- *InLarge* (for the MacIntosh) enlarges the image on the screen like Zoomtext but does not include screen reading.
- *JAWS (Job Access with Speech)* does not modify color or print size but does allow the user to hear what is on the screen.

An additional software program is the Versatile Image Processor (see Table 1), which allows the user to scan a document as text. The user can then enlarge the document, improve its contrast, and choose from various display alternatives. In addition, users can use speech output with magnification in this software program (Su & Uslan, 1998).

Universal Design for Learning (UDL) recommendations are steadily improving the ability to make modifications within commonly used software. These features will increase accessibility to information for many people with low vision. The consistent implementation of the recommended guidelines may eliminate the need for many of these devices in the future.

Time

In the environmental cue component of Corn's model, *time* and *space* refer to making time-efficient decisions about visual information and considering frequency, speed, and distance when making effective presentations (Corn, 1989). In this capacity, educators can use computers in converting one medium to another (e.g., visual to tactile, tactile to auditory) for people with low vision.

Magnifications can often be altered for individual needs through the use of computers.

Table 1 provides information on the following aids:

- The Braille'n Speak allows Braille users to take notes on a portable Brailler that can then be transcribed into standard text.
- The Nomad from the American Printing House for the Blind adds speech to tactile graphics. People with low vision can develop a "talking map" using the Nomad and a computer.
- Kurzweil readers are compatible with computers and use synthesized speech to read the text aloud at varying speeds. Version 1000 is made specifically for the visually impaired; Version 3000 is designed for people with learning disabilities but also can be used with children with visual impairments.
- Open Book, Outspoken (for MacIntosh), and IBM Screen Reader are other examples of scan/read software programs that use speech synthesizers to read text in a computer program.
- Learning Keys and Talking Typer for Windows provide verbal and visual feedback to people learning to use the computer keyboard.

Final Thoughts

Corn (2000, p. 905) summarized the importance of technology for all people, especially those with low vision, as follows: "In addition to the strength that comes from knowing these [technology] options exist is a richness of experience that expands each of us when we more fully participate in ordinary, day-to-day tasks."

Technology is a critical tool that enhances the ability of children with low vision to function more independently. Whether the technology is simple or complex, the enhancement of environmental cues has a significant impact on the way children with low vision can utilize their functional vision. The

increasing sophistication of the computer has added the dimensions of speech, reading, and transcription to the repertoire of available aids for people striving to use their vision more efficiently. Technological advances, coupled with implementation of UDL guidelines, should bring exciting changes for people with low vision in the coming years.

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